Mathematical Modelling of Engineering Problems
Vol. 12, No. 4, April, 2025, pp. 1389-1398
Journal homepage: http://iieta.org/journals/mmep

Using Different Stress-Strain Models in Finite Element Analysis to Investigate the Relationship Between the Ultimate Strength of Cylindrical and Cubic Concrete Standard Specimens

Majed A. Khalaf, Jawad Abd Matooq*, Ansam Z. Thamer, Fareed H. Majeed

Department of Civil Engineering, University of Basrah, Basrah 61004, Iraq

Corresponding Author Email: jawad.abd-matooq@uobasrah.edu.iq

https://doi.org/10.18280/mmep.120429

Received: 5 December 2024
Revised: 6 February 2025
Accepted: 12 February 2025
Available online: 30 April 2025

Keywords:
ABAQUS, concrete damage plasticity, concrete cylinder, concrete cube, finite element method, stress-strain curve

ABSTRACT

A finite element simulation with concrete damage plasticity (CDP) model and four different stress-strain curves chosen from the literature, has been employed to investigate the relationship between the ultimate strength of cylindrical and cubic concrete standard specimens. The study used ABAQUS software to track the mechanical behavior of these two types of specimens for normal concrete of grades from 20 to 50 MPa under monotonic compression loading. The main result of the study is that the stress-strain curve proposed by Carreira, among the studied models, give the best fit of this relationship in comparing with the ratios adopted by Eurocode. The paper emphasizes that before adopting a specific concrete stress-strain curve for the numerical simulation of a complex member under complex conditions, it is essential to examine the accuracy of that model for more simpler cases. It is obvious from the four studied stress-strain models that the ratio of f_{cy}/f_{cu} is increasing with concrete grade, which means there is more attend for the two strengths to approach each other, however the Eurocode table does not track this increasing and give only oscillating data.

1. INTRODUCTION

The compressive strength is the most important property of concrete used in design calculations for plain and reinforced concrete elements. It is also used quantitatively or qualitatively to express the other properties or reflect the quality and durability of concrete. Different countries adopting different codes of engineering practice used different shapes and sizes of test specimens to obtain the characteristic compressive strength of concrete. The mostly used test specimens are the cylinders and cubes. Many countries use cylinder specimens with dimensions (D=150 mm, h=300 mm), such as the United States, Canada, France, Australia, South Korea, and other countries. On the other hand, countries such as the UK, Germany, South Africa, Iraq, and many others use 150mm cube specimens. It is the basic question: Which test specimen is more representative of the compressive strength of concrete in its actual state for different structural concrete members? The other important question is how to convert the test results of compressive strength between these two different-shaped standard samples when required. The cylinder compressive strength is more preferable, both in design calculation and academic studies. The cube sample, on the other hand, is more preferable from practical aspects to be used in laboratories. One of the reasons is the cylinder samples required capping at the two loaded faces to reduce the friction and stress concentration between the platen of the test machine and the upper and lower faces of the sample, whereas the cube sample does not require that capping.

Some countries such as Iraq, South Africa, and some of the European and other countries, used cubes as a standard test specimen, while their design codes such as EN 1992-1-1 [1], adopt the characteristic cylinder compressive strength in its design equations. So, they need to convert the cube results to cylinder equivalence before using them in design calculations. For this reason, the Eurocode EN 206 includes Table 1 [2], which is reproduced here as Table 1 and referred to as EN-Table throughout this study.

Table 1. Compressive strength classes for normal-weight and heavy-weight concrete (Table 12 of EN-206) [2]

Compressive Strength Class	Cylinder Strength *F*ck, Cyl (N/mm^2)	Cube Strength *F*ck, Cube (N/mm^2)	*F*ck, Cyl/*F*ck, Cube
C8/10	8	10	0.80
C12/15	12	15	0.80
C16/20	16	20	0.80
C20/25	20	25	0.80
C25/30	25	30	0.83
C30/37	30	37	0.81
C35/45	35	45	0.78
C40/50	40	50	0.80
C45/55	45	55	0.82
C50/60	50	60	0.83
C55/67	55	67	0.82
C60/75	60	75	0.80
C70/85	70	85	0.82
C80/95	80	95	0.84
C90/105	90	105	0.86
C100/115	100	115	0.87